FYI-0794-000937

Chemical: 2,2'Azobisisobutyronitrile, CAS #78-67-1

Du Pont Trade Name: "Vazo" 64

Manufacture: Deleted ← Confidential Business Information

Processing:

Prime Application: Vinyl polymerization initiator. Closed system processing used in manufacture and usage.

Environmental Release:

(a) Manufacturing: Less than 1 lb/yr. to atmosphere
25M-35M lbs/yr to plant waste water treatment facility
7.5M-10M lbs/yr contract incineration

(b) Processing: <1 lb/yr to atmosphere.

Worker Exposure:

(a) Manufacturing - Number of workers exposed: 33
(Operations 17, Maintenance 5, Quality Control 4, Warehouse/Shipping 4, Other-Technical 3
Exposure Level: (Range 0.13-0.56 mg/m^3 12-hr TWA) 0.3 mg/m^3 average 12-hr TWA
Exposure Duration: Nominal = 130 days/yr. Actual (25% exposure) = 33 days/yr

(b) Processing: Number of workers exposed = 13.
Exposure Level <0.5 mg/m^3 8-hr TWA
Exposure Duration = 2 days/yr

Exposure Control:

- Du Pont Acceptable Exposure Limit (AEL): 1.0 mg/m^3 8-hr TWA
  : 0.7 mg/m^3 12-hr TWA
- Packaging following manufacture in separate air conditioned room.
- Pack out station equipped with dust collection system.
- Use of dust resistant gloves during product handling.
- Hosing of work areas twice per shift to reduce dust accumulation during manufacture.
- Refrigerated drum storage at processing plant to minimize product decomposition.

Toxicity: Report numbers in parentheses.

- Oral: Approximate Lethal Dose (ALD) = 670 mg/kg (male rats) (HLR 27-62)
  = 450 mg/kg (female rats) (HLR 27-62)
- Primary Skin Irritation and Sensitization (PSIS): No irritation or sensitization (HLR 88-62)
- Eye Irritation: Temporary irritant (HLR 88-62)
- Inhalation: Approximate Lethal Concentration (ALC) = 12 mg/l (rats) (HLR 88-62)
- Mutagenicity: Ames test negative. Compound non-mutagenic (HLR 89-76)

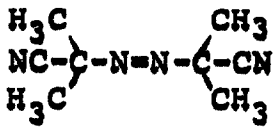
Attachments

- Du Pont Haskell Laboratory toxicity reports cited
- Du Pont Haskell Lab. Toxicity Summary on 2,2'Azobisisobutyronitrile
- Material Safety Data Sheet
- Product bulletin

KDDASTUR
1/30/84

HASKELL LABORATORY

Product Name: Vazo® 64
Chemical Name: Propanenitrile, 2,2'-azobis(2-methyl- (9CI)
Propionitrile, 2,2'-azobis(2-methyl- (8CI)
Synonyms: α,α'-Azobis(isobutyronitrile)
α,α'-Azodiisobutyronitrile
2,2'-Azobis(isobutyronitrile)
2,2'-Azodiisobutyronitrile
α,α'-Azodiisobutyric acid dinitrile
Aceto AZIB
Porofor-57
Porophor N (also Porofor N)
AIBN
AZDH
Genitron
AIVN
Pianofor AN
CAS Registry No.: 78-67-1
Chemical Structure:



Physical Properties

Molecular Weight:	164.21 (2)
Form:	White crystalline solid (1)
Specific Gravity:	1.128 (1)
Melting Point:	105-107°C (decomposes) (1)
Decomposition:	Vazo® 64 decomposes on heating (about 100°C), liberating nitrogen and forming two free radicals. Under certain conditions these free radicals can combine to form tetramethylsuccinonitrile [TMSN]. TMSN is highly toxic by inhalation, and although it is a high melting solid (168°C), it can readily vaporize even at room temperature (1). The TLV®-TWA established by OSHA (6) for TMSN is 0.5 ppm (3 mg/m^3) and the ACGIH recommends a Short Term Exposure Limit of 1.5 ppm (9 mg/m^3). TMSN in both solid and vapor form is capable of penetrating the skin and mucous membranes (1).

Physical Properties (Contd)

Solubility:	Soluble in methanol, ethanol and many other organic solvents (1,2). It is insoluble in water (1,2,13,14).
Autoignition Temperature:	842°F (dust in air); 284-750°F (as a solid) (1).
Flammability:	It burns brightly, though mildly, and completely in air (1).
Explosibility:	It is not shock sensitive. A mild explosion may occur if temperatures are allowed to exceed 140°F when stored in a closed container. Dispersions in air are explosive and extremely easy to ignite. The lower explosion limit of the dust in air is 0.02 g/l (1). A 30% solution in acetone was reported to have exploded (1,2,5).

Threshold Limit Values

None were found.

FDA Status

The following are listed under Title 21 Code of Federal Regulations (3):

- Vazo® 64 [2,2'-azobis(isobutyronitrile)] may be safely used for cross linking unsaturated polyester resins intended for repeated use in contact with food, provided the quantity does not exceed 1.5% by weight of the finished resin. (Section 177.2420, Food Additives Regulations).

- Vazo® 64 may be safely used as a polymerization initiator in components of paper and paperboard in contact with aqueous and fatty foods and also dry foods. (Sections 176.170 and 176.180, Food Additives Regulations).

- Vazo® 64 may be safely used as a component of adhesives used in food packaging. (Section 175.105, Food Additives Regulations).

TOXICITY

A. Acute

1. Oral

- Approximate Lethal Dose [ALD] female rats = 450 mg/kg (8)
  male rats = 670 mg/kg (4,8).

  Toxic signs were discomfort, irritability, inactivity, convulsions, weight loss and slight polyuria. Gross pathological changes were not detected at non-lethal doses, but at lethal doses liver damage, congestion of the brain, and lung, kidney and stomach damage were noted (8).

- LD50 (mice) = 700 mg/kg (11).

2. Skin

- When tested as a 25% ointment in "Carbowax" 1500 or dimethyl phthalate on the abraded skin of guinea pigs, there was no evidence of significant irritation or sensitization (9).

- Porofor-57 was applied in powdered form to the tails of five mice and the tails of an additional five mice were immersed in an aqueous solution of the powder. No local signs of irritation or symptoms of absorption were noted following five daily four-hour treatments (11).

3. Eyes

- Male rabbits received doses of 10 mg of Vazo® 64 either as the powder sprinkled on the surface of the eyes or as a suspension in propylene glycol instilled into the conjunctival sacs. The left eyes were washed and the right ones were not. Vazo® 64 produced temporary conjunctival irritation but no corneal or iritic injury (9).

4. Inhalation

- Rats were exposed to various concentrations of Vazo® 64 in air. No rats were killed at any of the doses tested, with 12 mg/l (12,000 mg/m^3) for four hours being the most severe exposure. Clinical observations during the exposures included

included deep breathing, eye irritation, discomfort and pallor and, during the recovery period, nervousness, ruffled fur and weight losses were noted. Pathological findings (two weeks post exposure) were kidney damage and slight hypotrophy of the thymic medulla (9).

- White mice were exposed for one hour to the decomposition products from Porofor-57 heated at various temperatures. Only a slight stimulation was seen at 25-30°C. This increased during heating at 40-45°C. Heating to 70-80°C caused sharp disruption of breathing, spasms and death to all of the mice after 10-30 minutes exposure. Rusin speculated that HCN was formed during the decomposition and was the cause of death.

  Rusin also exposed rats for two-hour periods every day for 10 days to the vapors from Porofor-57 heated to 70-80°C. An undisclosed number of animals died and, following sacrifice and autopsy, a great deal of organ damage was noted. He also attributed this toxicity to the decomposition products of Porofor rather than to Porofor itself (11).

- Inhalation toxicities of volatile, thermal decomposition products given off at 150-250°C from 13 cellular plastics, some containing azodiisobutyronitrile as the foaming agent, were slightly higher than those not containing the foaming agent. Nevertheless, the toxicity of the volatiles from any of the above plastics was negligible, the only effect being irritation of the upper respiratory tract (16).

5. Intraperitoneal Injection

   - LD50 (mice) = 25 mg/kg (10).
   - LD50 (mice) = 450 mg/kg (11).
   - Rusin (12) found that the injection of azobis-(isobutyronitrile) into rats intraperitoneally, intravenously and intratracheally resulted in the production of free HCN in the blood, liver brain and lungs. Theorizing that the toxic effect of azobis(isobutyronitrile) was due to

the metabolic formation of HCN, he treated his animals with the HCN antidotes--hyposulfite and sodium nitrite. These counteracted the lethal effect of the test compound administered by inhalation but were less effective in treating orally-induced intoxications. Rusin regarded HCN as the basic cause of azobis(isobutyronitrile) poisoning (12).

B. Prolonged Studies

1. Oral

- Five rats were fed 200 mg/kg per day of α,α'-azobis(isobutyronitrile). One died after three treatments, one after six treatments and three survived eleven treatments. All rats lost considerable weight. The only gross pathology noted at sacrifice were peripheral lividity and distended stomachs with slightly red mucosae. Microscopically, no significant changes in the organs were observed (4).

- Repeated oral administrations (dose unspecified in the abstract) of azobis(isobutyronitrile) decreased serum glycoprotein and albumin levels and increased leucine aminopeptidase, glutamic-oxalacetic transaminase, glutamic-pyruvate transaminase, glucose-6-phosphate dehydrogenase, aldolase and β-glycuronidase activities in rats. The intensity of these biochemical changes corresponded with the intensity of the lesions observed in the liver, kidney, and other organs (15).

2. Inhalation

- Rusin (11) exposed five rats to the vapors produced from Porofor-57 heated to 70-80°C for 2 hours/day for 10 days. The HCN concentrations did not exceed 1.4-1.6 mg/m^3. One rat died and morphological changes similar to those seen in intoxication with nitriles and cyanides were observed (11).

C. Carcinogenic Potential

- Azoisobutyronitrile showed "no carcinogenic properties" in BD-strain rats after chronic administration. The Preussmann et al paper (17) did not specify the dose, duration or route of administration (oral in drinking water, oral by gavage, or subcutaneous).

- In an attempt to correlate local greying of hair in mice with mutagenicity and carcinogenicity, Boyland and Sargent (18) treated mice with x-rays and with radiomimetic drugs. One of the compounds tested was azobis(isobutyronitrile). This compound was injected intradermally (0.05 ml of a 0.03M solution in saline) into four sites on each of five mice. Greying of the hair occurred at 5% of the sites (0% in the saline controls) and the latent period averaged 22 days. Thus, azobis(isobutyronitrile) showed very little effect in this study.

- α,α'-Azodiisobutyronitrile was tested for activity as a cytotoxic agent in a test which used implants in rats of the Walker tumor. The total dose of 800 mg/kg was administered intraperitoneally in daily doses during the first 10-12 days following implantations. This dose was determined through preliminary range finding studies with mice and rats. (These range finding data were not included in the paper). Azodiisobutyronitrile did not inhibit tumor growth by >45% and did not appear to have an effect which was in any sense directed preferentially towards the tumor (22).

D. Mutagenic Potential

- 2,2'-Azobis(isobutyronitrile) was tested in Salmonella typhimurium strains TA 1535, TA 1537, TA 1538, TA 98 and TA 100 in concentrations up to 2500 µg per plate in the activated plate assay and up to 5000 µg per plate in the non-activated plate test. It was not mutagenic either in the presence or absence of a liver microsomal activation system (19).

E. Teratogenic Potential and Reproductive Effects

No information was found.

F. Effects on Humans

- "In one plant in Ontario azobis(isobutyronitrile) has been in use as a blowing agent for the production of vinyl foam. Eight people at work in this process have experienced headache and nausea. There is some tolerance reported because newer workers are affected whereas older ones are not. Headaches, nausea, convulsions and coma were reported in workers making vinyl foam with this blowing agent in Germany. The blowing agent itself is only moderately toxic on inhalation or ingestion. When heated, it decomposes, releasing nitrogen and tetramethyl-succinonitrile. Small amounts of hydrogen cyanide (less than 1 ppm) are also produced. Tetramethyl-succinonitrile is quite toxic. It is a strong convulsant in experimental animals and in man" (20).
- The toxicity of azoisobutyronitrile (Porophor N) to humans when used as a foaming agent in plastics manufacture is addressed in a monograph (21). Its toxic effects are attributed to one of its decomposition products--tetramethylsuccinicdinitrile.

G. Aquatic Toxicity

No information was found.

REFERENCES

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Philip J. Lardear:md
May 19, 1978

DU PONT

MATERIAL SAFETY DATA SHEET

IDENTIFICATION

Name
Vazo® 64 Polymerization Initiator
Grade

Synonyms Azobisisobutyronitrile, Azoisobutyronitrile
CAS Name
Propane nitrile, 2-methyl, 2,2'-azobis
I.D. Nos./Codes NIOSH Reg No. UG0800000
Wiswesser Line Notation: NCX''N:NX''CN
Manufacturer/Distributor
E. I. du Pont de Nemours & Co. (Inc.)

Address
Wilmington, DE 19898

Chemical Family
Azonitrile
Formula
$(CH_3)_2C(CN)N=NC(CH_3)_2CN$
CAS Registry No.
78-67-1
Du Pont Registry No.

Product Information and Emergency Phone
(302) 774-2421

Transportation Emergency Phone
(800) 424-9300

PHYSICAL DATA

Boiling Point, 760 mm Hg
Not applicable
Specific Gravity
~1.1 Bulk Density ~25 lbs/ft^3

Vapor Density
Not applicable
% Volatiles by Vol.
<0.1 at 21°C (70°F)
Form Solid ***Appearance*** Powder
pH Information
Neutral

Melting Point ~100°C (212°F) Caution: DO NOT attempt to verify; decomposition can be violent
Vapor Pressure
Negligible at room temperature

Solubility in H_2O
<1%
Evaporation Rate (Butyl Acetate = 1) 0

Color White ***Odor*** None
Octanol/Water Partition Coefficient

HAZARDOUS COMPONENTS

Material(s)	***Approximate %***
Vazo® 64	100%

HAZARDOUS REACTIVITY

Instability
Unstable with heat.
Incompatibility
Powerful inorganic oxidizers, such as nitric acid.
Decomposition Thermal decomposition releases nitrogen which, in a confined space, can be at hazardous pressure. Above Self-Accelerating Decomposition Temperature (SADT), 50°C (122°F), this is very rapid. Vapor of decomposition products is highly toxic and may be fatal if inhaled.
Polymerization: Will not occur.

FIRE AND EXPLOSION DATA

Flash Point *Method* *Autoignition Temperature*

Not applicable 295°C (563°F)

Flammable Limits in Air, % by Vol.

Lower 0.02 g/L

Upper Not determined

Fire and Explosion Hazards Flammable solid. Material may erupt if exposed to heat (above 50°C or 122°F) or fire. Dust forms explosive mixtures in air and an eruption of drums from exposure to heat may form explosive dust mixtures. Static electricity is a likely ignition source for dust; therefore handling equipment should be metal and should be grounded. Extinguishing Media: Water spray or deluge. CO_2, dry chemical or foam may be used on small fires.

Special Fire Fighting Instructions Evacuate area immediately. Wear air supplied respirator, stay upwind and avoid smoke and flame. Fight fires with sprinkler or deluge system or remotely-operated hydrant with monitor nozzles. Cool containers and wet exposed material with water spray. Do not approach a large fire because of possible rapid decomposition and rupture of containers. Consult Du Pont for advice on subsequent clean-up.

HEALTH HAZARD INFORMATION

Exposure Limits Vazo® 64 is not specificially regulated as a toxic or hazardous substance by OSHA. Limits for nuisance dusts are: OSHA 8-hour Time Weighted Average (TWA) = 15 mg/m^3 total dust, 5 mg/m^3 respirable dust; ACGIH TLV®-TWA = 10 mg/m^3 total dust, 5 mg/m^3 respirable dust. Du Pont recommends the ACGIH limits. Also, a potential decomposition product, tetramethylsuccinonitrile, has the limits: OSHA 8-hour TWA and ACGIH TLV®-TWA = 0.5 ppm or 3 mg/m^3, with no skin contact.

Significant Routes and Effects of Exposure

May irritate eyes.
Harmful if dust is inhaled. Vapor of decomposition products is highly toxic.
LD50 (oral, mouse) = 700 mg/kg (see Reference 2, page 4).

Safety Precautions

Avoid contact with eyes.
Avoid breathing dust. Do not breathe decomposition products.
Wash thoroughly after handling.

First Aid

Eye Contact: Immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.

If Swallowed: Induce vomiting immediately by giving 2 glasses of water and sticking finger down throat. Call a physician. Never give anythin by mouth to an unconscious person.

If Vazo® 64 or its Decomposition Products Are Inhaled: Remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mou If breathing is difficult, give oxygen. Call a physician.

PROTECTION INFORMATION

Ventilation Good general ventilation should be provided to keep dust concentrations below nuisance dust exposure limits and to prevent the formation of explosive dust mixtures in air.

Personal Protective Equipment

Dust goggles.
Respirator approved for dust and organic vapors, where dusty conditions exist or where tetramethylsuccinonitrile exposure limits may be exceeded.
Have available air-line respirator or self-contained breathing apparatus for decomposition products.

Other

Static Electricity: To avoid static electricity when dissolving in flammable solvents, Vazo® 64 should first be transferred to an electrically grounded, open metal container or hopper.

DISPOSAL INFORMATION

Aquatic Toxicity

Spill, Leak or Release

Transfer to unsealed drums without creating dust and refrigerate. Contaminated floor may be flushed with water to chemical sewer. Do not vacuum. Use spark-proof equipment. Comply with federal, state and local regulations on reporting releases.

Waste Disposal

Comply with federal, state and local regulations. Call Du Pont for disposal information.

SHIPPING INFORMATION

Transportation

DOT Hazard Class.*: Flammable Solid
Special Permit BA-3350
DOT Shipping Name*: Flammable Solid N.O.S. [2,2'-Azobisisobutyronitrile]

IMCO Class.: 4.1

UN No.: 1325 (IMCO 2952)
NA No.:

RQ Quantity*:

**49 CFR 172.101*

Shipping Containers

Fiber drums and polyethylene sample bags.

Storage Conditions Store in a refrigerator or out of sun and in cool, dry place below about 75°F (24°C); higher temperatures cause decomposition. Above about 122°F (50°C), decomposition may become violent, yielding toxic products. Do not store with strong oxidizing agents. Keep away from ignition sources. Do not smoke. Store in original vented container; do not transfer to tightly sealed containers. Automatic water sprinkler or deluge system recommended.

ADDITIONAL INFORMATION AND REFERENCES

References: For further information, see Du Pont Properties, Uses, Storage and Handling bulletin "Vazo® Polymerization Initiators" and Du Pont Technical Information Sheet "Instructions for Warehousemen."

NIOSH "Registry of Toxic Effects of Chemical Substances," 1979.

DU PONT

VAZO®

POLYMERIZATION INITIATORS

Properties, Uses, Storage and Handling

DU PONT

REG. U.S. PAT. & TM. OFF.

TABLE OF CONTENTS

NOTICE: *VAZO*® polymerization initiators are hazardous materials. A thorough understanding of their properties is needed to ensure safe handling. You are urged to read the sections in this bulletin pertaining to storage, handling and safety recommendations.

INTRODUCTION

The three commercial *VAZO** Polymerization Initiators, *VAZO* 52, *VAZO* 64 and *VAZO* 67 are white crystalline solids that are efficient free-radical sources. They are used in vinyl polymerizations and chain reactions such as chlorinations. The grade number is the Celsius temperature at which the half-life in solution is ten hours.

Although 2,2′-azobis(2-methylpropanenitrile), *VAZO* 64, has been known since 1896,[1] its use as a free radical source was not recognized until the late 1940's when its efficacy as a polymerization initiator was first reported.[2] *VAZO* 52 is 2,2′-azobis(2,4-dimethylpentanenitrile) and *VAZO* 67 is 2,2′-azobis(2-methylbutanenitrile).** All three function similarly. Unlike initiators of the peroxide type, *VAZO* polymerization initiators decompose to free radicals in a broad variety of solvents at very nearly first order rates, with no evidence of induced chain decomposition.[3] It is this lack of induced decomposition that leads to the increased efficiency of *VAZO* polymerization initiators in polymerizations[4] and other reactions. They can be used in bulk, solution and suspension polymerizations, and use in emulsion polymerizations has also been reported.[5] Because these initiators do not produce oxygenated residues, they are well suited for use in pigmented or dyed systems that may be susceptible to oxidative degradation.[6] Furthermore, they do not introduce light-sensitive oxygenated end-groups into polymers.

Chemical Abstracts Service Registry numbers for *VAZO* Polymerization Initiators are as follows:

VAZO 52	4419-11-8
VAZO 64	78-67-1
VAZO 67	13472-08-7

DU PONT *VAZO*® POLYMERIZATION INITIATORS

- are safer to handle than peroxides
- are not shock sensitive
- contain no oxygen
- cause little crosslinking
- can be mixed with each other and with peroxide initiators in vinyl polymerizations to optimize process variables such as cycle time and heat-release profile
- polymerize monomers containing amine or mercaptan groups without discoloration or other side-reactions.

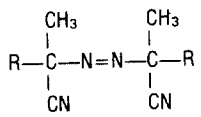
* Reg. U.S. Pat. & Tm. Off., Du Pont Company

[1] Superscript numbers in parentheses refer to REFERENCES AND NOTES on page 14.

** Other names sometimes used:
VAZO 52 2,2′-azobis (2,4-dimethylvaleronitrile)
VAZO 64 2,2′-azobis (isobutyronitrile), AIBN
VAZO 67 2,2′-azobis (methylbutyronitrile)

PROPERTIES

VAZO Polymerization Initiators are crystalline solids with the following molecular structure:



where R = isobutyl in *VAZO* 52
methyl in *VAZO* 64
ethyl in *VAZO* 67

The trans isomers predominate. While *VAZO* 64 behaves as a single compound melting slightly above 100°C, *VAZO* 52 can be readily separated into components melting at 56-57°C and 75-76°C. One of these is a meso form and the other a dextro-levo pair. Since the latter has not been resolved, it is not possible to relate structure to melting point. *VAZO* 67 must also exist in two forms, but they have not been separated; the mixture melts at about 49°C.

Specifications and typical properties are shown in Table I.

Solubility

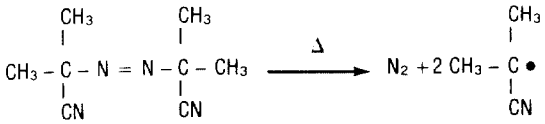
VAZO polymerization initiators are essentially insoluble in water, sparingly soluble in aliphatic hydrocarbons and soluble in functional compounds and aromatic hydrocarbons. Solubility data are shown in Table II.

The least soluble in water is *VAZO* 52; the most soluble in organic solvents is *VAZO* 67.

Thermal Stability

Differential thermal analyses on dry *VAZO* initiators show exotherms beginning at 55°C for *VAZO* 52 and 106°C for *VAZO* 64.

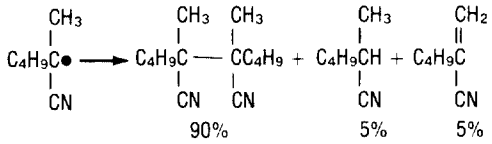
In solution *VAZO* decomposes on heating, liberating nitrogen and forming two free radicals (probably through a two-step reaction).[7] For *VAZO* 64, the reaction is:



Since the decomposition is first-order,[3] the rate of free-radical formation can be controlled by regulating the temperature. The half lives in solution as functions of temperature are shown in Figure 1. The rates of decomposition are essentially independent of the solvent as shown in Table IV.[4a,9] The half lives of the isomers of *VAZO* 52 are identical. The activation energies of the decompositions are about 31 kilocalories (130 kilojoules) per mole.

Ideally, all the radicals formed in the decompositions react with vinyl monomer, chlorine or other suitable substrate, to initiate chain reactions. No initiator, however, is 100% effective. Some radicals react with each other, even in the presence of an excess of monomer. The extent of this side reaction varies from almost nil to as much as 50%, depending on the reaction conditions. In the absence of a suitable substrate, all the radicals react with each other. Of the products formed in this side reaction, about 90 percent is the radical dimer, with 5 percent of each of the disproportionation products.[8]

To illustrate, the following are the principal products formed when the radicals from *VAZO* 52 react with each other:



The dimer formed from *VAZO* 64, TMSN, is toxic; see Inhalation Hazards on page 6.

The photochemical decomposition of 2,2′-azobis-(isobutyronitrile) to initiate polymerization has also been reported;[2c] all three initiators absorb at 350 nm.

TABLE I

PROPERTIES, SPECIFICATIONS AND TYPICAL ANALYSES*
DU PONT *VAZO*® POLYMERIZATION INITIATORS

	***VAZO* 52**	***VAZO* 64**	***VAZO* 67**
Molecular formula	$C_{14}H_{24}N_4$	$C_8H_{12}N_4$	$C_{10}H_{16}N_4$
Molecular weight	248.37	164.21	192.26
Bulk density, approx., lb/cu ft	25	25	25
kg/m³	400	400	400
Specific gravity	—	1.128	—
Specific heat,** cal/g•C	~0.4	~0.4	~0.4
kJ/kg•K	~1.7	~1.7	~1.7
Heat of combustion,† kcal/g•mol	—	1208	—
kJ/kg•mol	—	5.05	—

	Specs.	**Typical Analyses**	**Specs.**	**Typical Analyses**	**Specs.**	**Typical Analyses**
Assay, wt%	98 min	99	98 min	99	98 min	99
Water, wt%	0.50 max	0.05	0.50 max	0.1	0.50 max	0.2
Iron, ppm	20 max	5	20 max	6	20 max	6
Acetone insolubles, wt%	0.15 max	0.03	0.1 max	0.03	0.15 max	0.03
Color, APHA, as 2% solution in dimethylformamide	25 max	13	15 max	13	25 max	15

* Typical properties are based on historical production performance. Du Pont does not make any express or implied warranty that these products will continue to have these typical properties. Du Pont test methods are available on request.
** Calculated
† Calculated. S ⟶ H_2O (liq.) + CO_2↑ + N_2↑

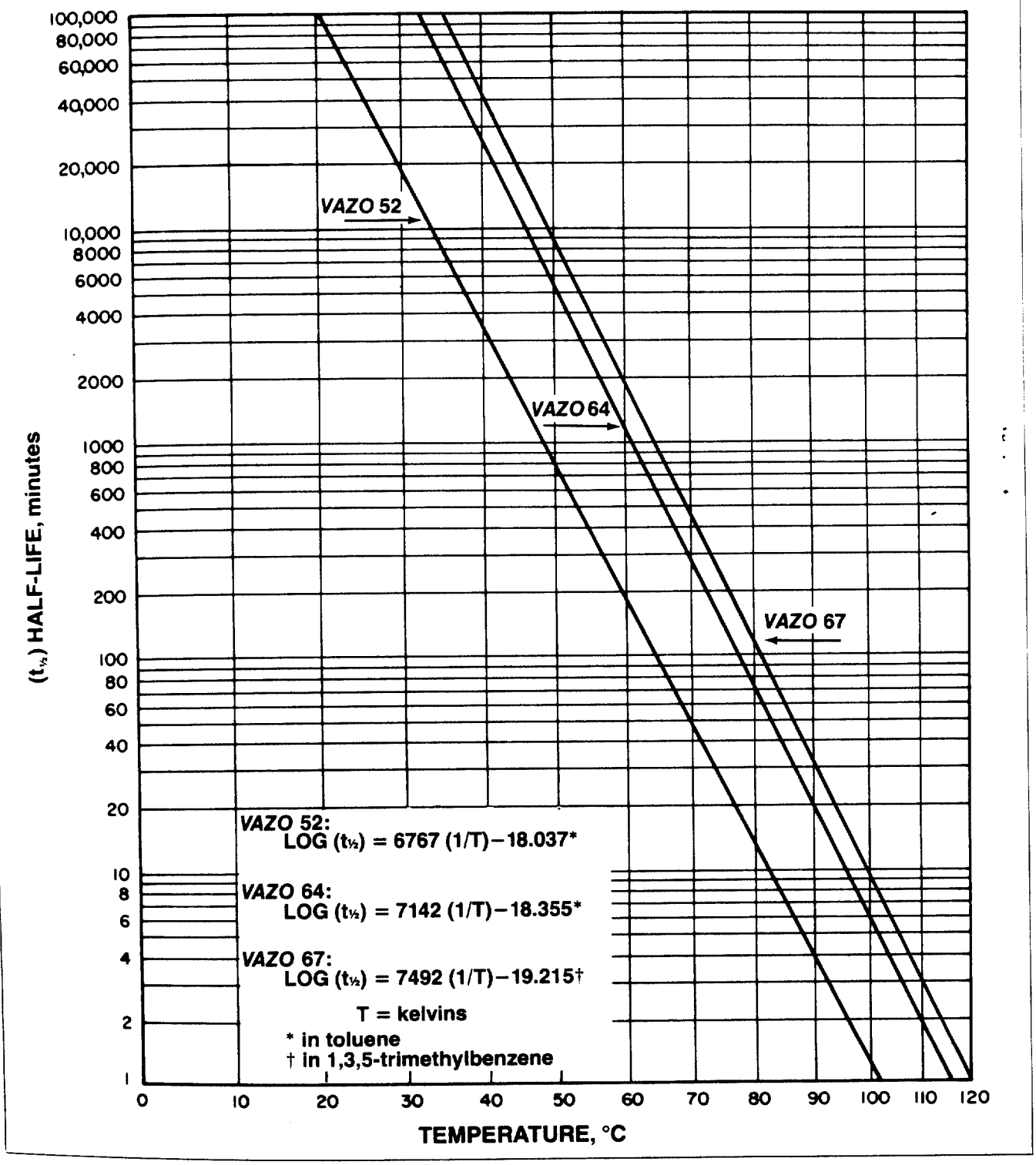
TABLE II
SOLUBILITIES OF *VAZO*® POLYMERIZATION INITIATORS
(grams per 100 grams solvent)

SOLVENT	*VAZO* 52		*VAZO* 64		*VAZO* 67
	at 0°C	at 25°C	at 0°C	at 25°C	at 25°C
Acetone	39	75	12	—	>185
Acrylonitrile	—	—	20	38	—
Benzene	49	108	<1	11	—
Butyl Cellosolve	—	—	—	2	—
Carbon tetrachloride	—	—	—	0.7	—
Chloroform	54	100	17	25	—
Dibutyl phthalate	—	23	—	—	—
Dichloromethane	—	—	21.5	40	>185
Diisobutyl ketone	—	—	2	6	—
Dioctyl phthalate	—	<1	—	—	—
N,N-dimethylacetamide	—	—	7	21	—
Dioxane	—	—	<1	—	—
Ethanol (absolute)	9	20	—	2.7	75
Ethanol 2B	—	—	—	2.7	—
Ethyl acetate	35	100	5	14	>100
Ethyl ether	—	—	—	4	43
Ethylene chloride	—	—	4	23	—
Formamide	—	—	—	0.5	—
FREON® 12 (dichlorodifluoromethane)	—	—	0.1	—	—
FREON® 113 (trichlorotrifluoroethane)	—	—	<1	—	—
Heptane	4	6	—	0.5	2.8
Isopar K*	2	6	—	—	—
Isopropyl acetate	—	—	4	9	—
Isopropyl alcohol	5	22	—	0.7	83
Methanol (absolute)	11	39	2.5	7.5	161
Methyl isobutyl ketone	—	—	3	13	—
Methyl ethyl ketone	—	—	13	30	—
Methyl formate	—	—	10	26	—
Methyl methacrylate	28	85	4	10	—
Methyl methoxyacetate	—	—	8.5	20	—
Stoddard solvent	6	18	—	—	—
Styrene	27	96	3	8	—
Toluene	35	82	2	7	>185
Vinyl acetate	28	85	—	—	—
VM&P naphtha	5	18	—	—	—
Xylene	27	79	—	2.5	—
Water	—	0.009	<0.01	0.04	<0.1
White mineral oil (Nujol)**	0.2	0.3	—	—	—
Mixtures (50%-50% by weight)					
Benzene + N,N-dimethylacetamide	—	—	8	21	—
Benzene + Methyl formate	—	—	15	33	—
Benzene + Methyl methoxyacetate	—	—	8	20	—

*Reg. U.S. Pat. & Tm. Off., Exxon Co., U.S.A.
**Reg. U.S. Pat. & Tm. Off., Plough Inc. U.S.A.

FIGURE 1. THERMAL DECOMPOSITION OF *VAZO*® POLYMERIZATION INITIATORS

Half-Lives in Solution



PERSONAL SAFETY AND FIRST AID

Health Hazards

VAZO® 52 and *VAZO* 64 cause mild transient irritation to the eyes. Neither compound is a skin sensitizer, but in tests with laboratory animals, *VAZO* 52 shows evidence of being a slight skin irritant. *VAZO* 67 shows none of these effects but as a matter of good industrial hygiene, physical contact should be avoided.

VAZO Polymerization Initiators have slight to low oral toxicities as shown in Table III. Their decomposition products have similarly low oral toxicities with the important exception of tetramethylsuccinonitrile (TMSN) from *VAZO* 64. This compound is highly toxic orally and by inhalation; see the following section on inhalation hazards.

TABLE III
APPROXIMATE ORAL TOXICITY (mg/kg, rats)

Product	Azo Compound	Decomposition Products
VAZO 52*	>5000	5000
VAZO 64*	670	60**
VAZO 67†	982	1316

*Approximate Lethal Dosage (ALD)
**TMSN alone
†Lethal Dosage for 50 percent of test animals (LD_{50})

The dust of *VAZO* 64 gave a 4-hour approximate lethal concentration of 0.95 mg/L, which is moderately toxic. Suitable precautions should be taken to avoid breathing the dusts from any *VAZO* initiator. The problem is ameliorated by the need to avoid dust explosions (see Explosion Hazards on page 12).

Inhalation Hazards of Decomposition Products

When *VAZO* 64 decomposes, it forms free radicals. Under certain conditions, these can combine to form tetramethylsuccinonitrile (TMSN). TMSN is highly toxic by inhalation, and although it is a high melting solid (168°C), it can readily vaporize even at room temperature.

The U.S. Department of Labor (OSHA) has ruled that an employee's exposure to TMSN in any 8-hour shift of a 40-hour week shall not exceed an 8-hour time-weighted average of 0.5 ppm in air, or 3 mg/m³ (29 CFR 1910.1000, Air Contaminants).[10] It also cautions that, since both the solid and vapor are capable of penetrating the skin and mucous membranes, control of vapor inhalation alone may not be sufficient to prevent absorption of an excessive dose. The National Institute for Occupational Safety and Health (NIOSH) has recommended a ceiling of 6 mg/m³ (1 ppm) in air.[11]

In the absence of a polymerizable vinyl monomer, up to 90% *VAZO* 64 decomposes to TMSN. For this reason, Du Pont does not recommend the use of *VAZO* 64 as a blowing agent. The presence of a polymerizable monomer, however, greatly diminishes the amount of TMSN formed. The level of TMSN in the resulting polymer depends upon the amount of *VAZO* 64 used, its efficiency in the particular polymerization involved, the conditions of washing and drying of the polymer, and the temperatures and times involved in the further processing of the resins to finished articles. Under most processing conditions, residual TMSN in the polymer should not present a hazard to the fabricator or consumer.

Because of its high volatility, part of any TMSN formed in the polymer will be lost by volatilization in the finishing steps and in the further processing of the resin into finished product forms. These operations should therefore be carried out under good ventilation.

Methods for determining TMSN levels in polymers and in air are available upon request.[12]

The approximate lethal concentration (ALC, 4-hour exposure, rats) for TMSN in air is 16 ppm, about 0.1 mg/L. For the combined decomposition products of *VAZO* 67, the ALC is 8.7 mg/L; this material is only slightly toxic by inhalation. For the corresponding products from *VAZO* 52, the 4-hour ALC is between 1 and 6 mg/L.

Small quantities of highly toxic hydrogen cyanide, HCN, are found in these decompositions (about 80 ppm from *VAZO* 52 and 100 ppm from *VAZO* 64, by weight). The hazard of this quantity of HCN is minor compared with that of the TMSN formed from *VAZO* 64. The combined decomposition products of *VAZO* 52, for which the above ALC was determined, included this HCN.

Safety Precautions

For good industrial hygienic practice and because of the slight irritation discussed above, avoid contact of *VAZO* 64 and *VAZO* 52 with the eyes, skin and clothing. Wash thoroughly after handling.

Avoid creating dusty conditions, primarily to reduce the possibility of dust explosions and to minimize inhalation of the dust. All operations should be carried out with good ventilation.

Avoid heating *VAZO* Polymerization Initiators during handling or storage; see the section on Storage on page 11 for conditions causing self-accelerating decomposition. Decomposition releases heat, nitrogen gas

and, in the case of *VAZO* 64, highly toxic products that may necessitate the use of an air-line mask, rubber gloves and clean protective clothing.

First Aid

After contact of *VAZO* 52, *VAZO* 64 or their decomposition products with the eyes, flush with plenty of water for at least 15 minutes and call a physician. For skin contact, wash thoroughly with soap and water.

If *VAZO* 64 or its decomposition products are inhaled, the person should be removed to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Call a physician.

FDA STATUS

The following Food and Drug Administration rulings[10] concern the use of *VAZO* 64 as an initiator in the production of polymers for use in food packaging applications:

- *VAZO* 64, 2,2′-azobis(isobutyronitrile), may be safely used for cross-linking unsaturated polyester resins intended for repeated use in contact with food, provided the initiator content does not exceed 1.5 weight percent of the finished resin (21 CFR 177.2420, Polyester resins, cross-linked).
- *VAZO* 64 may be safely used as a polymerization initiator in components of paper and paperboard in contact with dry, aqueous or fatty foods (21 CFR 176.170, Components of paper and paper-

TABLE IV
RATES OF DECOMPOSITION OF *VAZO*® POLYMERIZATION INITIATORS IN VARIOUS ORGANIC SOLVENTS[9]
Work done at 80°C except where otherwise indicated.

	Rate Constant, Sec.$^{-1}$ $k \times 10^4$			Half-Life, Min. $t_{1/2}$*		
SOLVENT	***VAZO* 52**	***VAZO* 64**	***VAZO* 67**	***VAZO* 52**	***VAZO* 64**	***VAZO* 67**
Aniline	—	1.68**	—	—	68.7	—
n-Butyl alcohol	—	1.55**	—	—	74.5	—
N,N-dimethylaniline	—	1.83	—	—	63.1	—
Cyclohexanone	—	1.43	—	—	80.8	—
Dodecyl mercaptan	—	1.46	—	—	79.0	—
t-Amyl alcohol	—	1.40	—	—	82.5	—
Isobutyl alcohol	—	1.72†	—	—	67.2	—
1-Nitrobutane	—	1.43	—	—	80.8	—
Toluene	7.1[2d]	1.5-1.8††	—	16.3[2d]	78-64††	—
Xylene	5.80†	1.53	1.00	17.9†	75.5	116
Nitrobenzene	—	1.98	—	—	58.3	—
Glacial acetic acid	—	1.52[2c]	—	—	76.0	—
1,3,5-trimethylbenzene	—	—	0.825	—	—	140‡

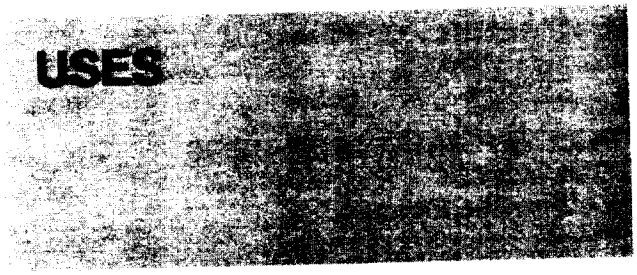
* $t_{1/2} = 0.693/k$
** At 82°C.
† At 77°C.
†† Range reported in literature
‡ At 78°C.

board in contact with aqueous and fatty foods, and 21 CFR 176.180, Components of paper and paperboard in contact with dry food).

- *VAZO* 64 may be safely used as a component of adhesives used in food packaging (21 CFR 175.105, Adhesives).

No FDA clearance is recorded for *VAZO* 52 or *VAZO* 67 in the Code of Federal Regulations.

In a 1965 letter to Du Pont, the FDA concluded that the use of *VAZO* 64, 2,2′-azobis(isobutyronitrile) presented no food additive problem when used as an initiator in the production of polyethylene and polyvinyl chloride (for fabrication into films) under conditions whereby the initiator levels did not exceed 0.08 weight percent for ethylene and 0.15 weight percent for vinyl chloride based on the monomer. In 1969, Du Pont received a similar letter on the use of *VAZO* 52 in PVC film. In 1971, the FDA withdrew all "opinion letters" including these. Users of *VAZO* 52 or *VAZO* 64 in polyethylene and polyvinyl chloride food packaging films are therefore urged to check the status of their products with the FDA.



Vinyl Polymerization Initiator

VAZO® 64 and *VAZO* 52 have been used for bulk, solution, emulsion, and suspension polymerizations of common vinyl monomers such as:

- vinyl chloride
- acrylonitrile
- styrene
- ethylene
- vinyl acetate
- vinylidene chloride
- methyl methacrylate
- methyl acrylate

They are also useful in the polymerization of unsaturated polyesters and in copolymerizations of vinyl compounds. *VAZO*® 67 appears to be similarly versatile.

The most useful temperature range for work with *VAZO* 64 or *VAZO* 67 is 45-90°C, although they can also be used outside this range; corresponding temperatures for *VAZO* 52 are 35-80°C. The amount used will vary from 0.01% or less to 1% or more, based on the amount of monomer, the desired reaction speed, the temperature, the expected molecular weight and other variables. Figure 2 shows the effect of temperature and initiator concentration on the rate of polymerization of vinyl chloride in laboratory experiments. These results were obtained with no inhibitor in the monomer; the presence of inhibitor would require an increase in the amount of initiator to achieve the same reaction rates.

In some polymerizations, *VAZO* can be added directly to the reaction vessel. However, it may be advantageous or necessary to dissolve or suspend the *VAZO* in a liquid which is then added at the beginning of, or continuously during the reaction. Care should be taken to avoid adding *VAZO* to overheated reactants and to avoid an excess of *VAZO*. In high-pressure processes, care must be taken to select solvents that do not freeze under pressure at processing temperatures. Table II lists solubilities for a number of solvents including some mixtures. Forming a paste with butyl phthalate or tricresyl phosphate greatly accelerates the rate of solution in unsaturated polyesters.

Table II indicates that *VAZO* 67 is considerably more soluble than the other grades. It should therefore be considered if the utmost in solubility is needed, e.g. to reduce solvent emissions (but see Hazards of Solutions section on page 12). *VAZO* 67 is also the initiator of choice if toxicity must be reduced in a system with the kinetics of *VAZO* 64.

Advantages of *VAZO* Polymerization Initiators

1. *VAZO* polymerization initiators yield less-energetic free radicals than those produced by most peroxides; they therefore tend to give fewer side reactions and their efficiencies are often higher. They can be used at lower concentrations without sacrifice in polymerization rate. This often reduces cost. Another economic factor is low molecular weight, which is particularly advantageous with *VAZO* 64.
2. *VAZO* can be stored and handled at more convenient temperatures than many peroxides with similar half lives. Room temperature storage (preferably below 75°F, 24°C) has proven satisfactory for *VAZO* 64 and *VAZO* 67 with little loss of activity and no fear of spontaneous combustion or explosion.
3. Since these *VAZO* polymerization initiators decompose to radicals that contain no oxygen, they do not incorporate oxygen into polymers. Polymers initiated by peroxides do contain oxygen, and often develop color on aging; it is often possible to avoid this by using *VAZO*.[13]
4. Since the free radicals formed from *VAZO* polymerization initiators are less energetic than those from peroxides, they abstract hydrogen less readily. The resulting polymers are therefore more linear.

5. The decomposition rates of *VAZO* polymerization initiators to form free radicals are not affected by metals or other additives or contaminants. Polymers can be made containing pigments that would decompose peroxides. On the other hand, *VAZO* polymerization initiators cannot be accelerated by additives such as cobalt naphthenate.

6. The radicals from *VAZO* polymerization initiators do not bleach most dyestuffs.

7. *VAZO* polymerization initiators are unaffected by a wide range of pH, and can function normally in a highly alkaline environment.

8. Although there are minor differences in the rates of initiation with different monomers, these differences are less than with peroxides.[2,4] *VAZO* polymerization initiators are therefore particularly useful in copolymerizations, in which they provide improved control of the monomer ratio.

9. The radicals from *VAZO* polymerization initiators are only very weak oxidizing agents. They can therefore be used to polymerize various susceptible compounds such as unsaturated amines, aldehydes, thioethers and mercaptans.

10. The *VAZO*® polymerization initiators have extremely predictable kinetics of decomposition, and are particularly useful in dual-initiator systems. They can be used with each other or with peroxides.

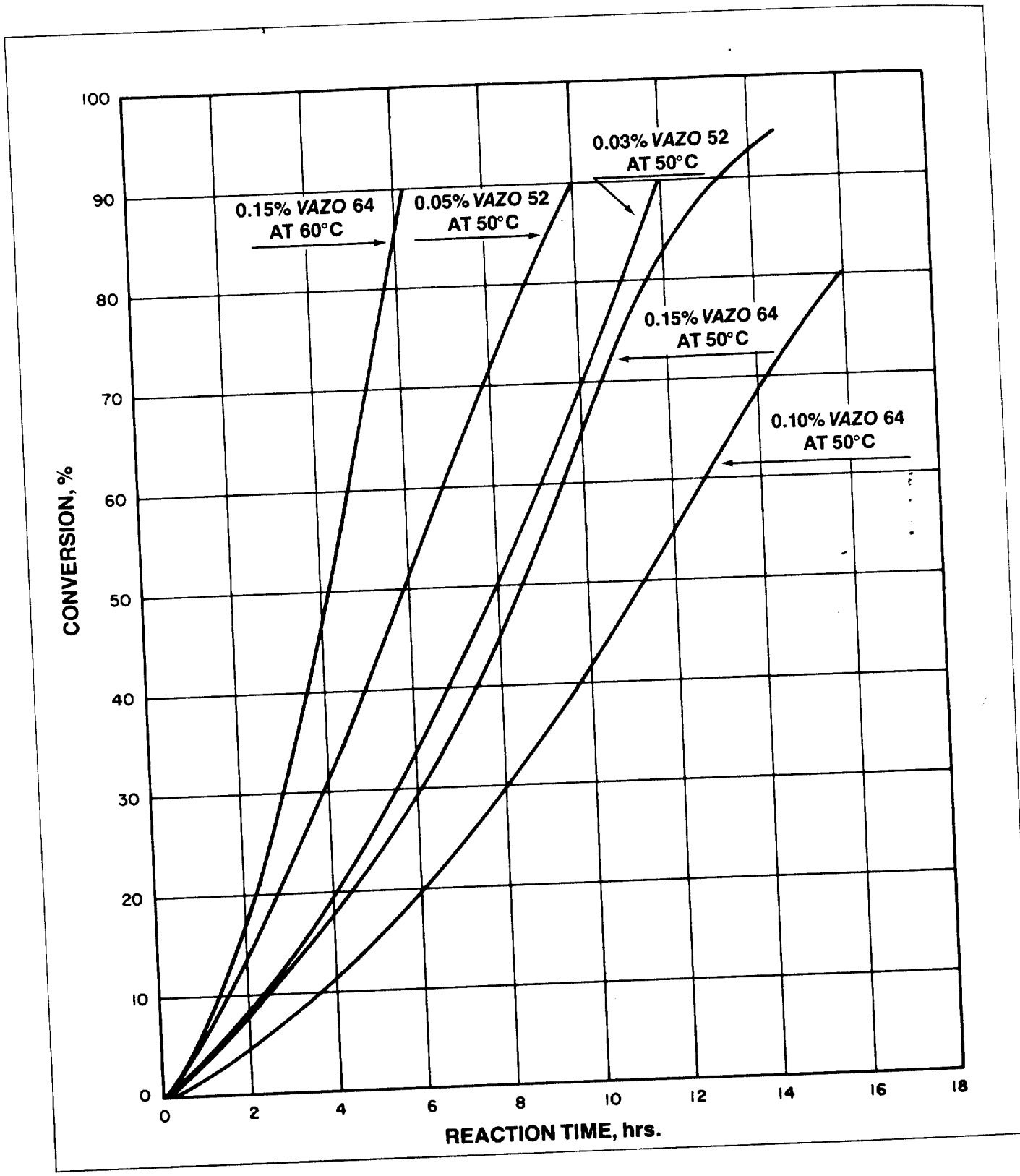
Non-polymerization Uses

In addition to initiating the polymerization of vinyl compounds, *VAZO* polymerization initiators are useful in initiating the addition of various compounds containing halogen, sulfur, phosphorus and silicon to olefins;[14] examples are chlorine, hydrogen sulfide, mercaptans and phosphines.

They can also be used as initiators for halogenations and for air oxidation of aromatic and aliphatic hydrocarbons and other compounds such as acrylonitrile, methyl methacrylate and vinyl acetate.[15]

The radicals can also be used for synthesis. When reacted with unsaturated compounds in more nearly equal molar ratios, monomers and oligomers containing two *VAZO*-derived radicals can result. These dinitriles can be further converted to amides, amines or acids.

FIGURE 2. EFFECT OF TEMPERATURE AND *VAZO*® CONCENTRATION ON RATE OF VINYL CHLORIDE SUSPENSION POLYMERIZATION



STORAGE AND HANDLING

Shipping Containers

VAZO Polymerization Initiators are available in 10 lb/4.53 kg and 50 lb/22.67 kg (net) fiber drums. *VAZO* Polymerization Initiators are regulated as Hazardous Materials by the Department of Transportation (DOT). The DOT proper shipping name for *VAZO* is FLAMMABLE SOLID, N.O.S. and the DOT Hazard Class is FLAMMABLE SOLID (49 CFR 172.101, Hazardous Materials Table).[10] The DOT identification number is UN 1325.

Shipment of *VAZO* 52 by private truck or common carrier (truck and cargo aircraft) must be made according to DOT special permit BA-1852, which must accompany the Bill of Lading. *VAZO* 64 and *VAZO* 67 are similarly covered by permit BA-3350. Customers are cautioned not to reship *VAZO* unless a special permit is obtained from DOT.

Storage

When *VAZO* Polymerization Initiators decompose, one of the products liberated is nitrogen gas which creates the potential for pressure increase. Toxic products discussed on page 6 are also formed. To prevent decomposition and maintain purity, *VAZO* polymerization initiators must be stored out of the sun, away from sources of heat, in a cool, dry place. Do not store in a tightly closed container such as a reactor, a sealed package other than the original shipping container, or a sealed storage area. Do not store in glass. The maximum storage temperatures are 10°C (*VAZO* 52) and 24°C (*VAZO* 64, *VAZO* 67).

Approximate decomposition rates in storage (i.e., in the solid state) are as follows:

	***VAZO* 64**	***VAZO* 52**
104°F (40°C)	2.5%/week	—
75°F (24°C)	0.6%/month	0.13%/day
50°F (10°C)	—	0.03%/day

The stability of *VAZO* 67 is comparable to that of *VAZO* 64. The rates double for each 5°C (9°F) increase in temperature. Good warehousing techniques should be used to minimize storage time.

VAZO polymerization initiators can cake on prolonged storage at elevated temperature. The tendency toward caking is reduced if lower storage temperatures are maintained. Cooled storage areas and refrigerated transport may therefore be necessary even with *VAZO* 64 and *VAZO* 67, especially during the summer months.

Self Accelerating Decomposition Temperature (SADT)

The SADT is the temperature at which rapid decomposition occurs after one week's storage in the largest commercial container. The latter is a 50 lb fiber drum. The SADT's are about 35°C (95°F) for *VAZO* 52, and 50°C (120°F) for *VAZO* 64 and *VAZO* 67. When the decomposition occurs, the sudden release of nitrogen blows the lid off the drum and discharges the contents as a fine dust (see Explosion Hazards, page 12). Charring takes place at the bottom of the drum, but actual ignition is rare and is usually due to a dust explosion. See page 12 (Hazards of Solutions) for self-accelerating decomposition of solutions of *VAZO*.

Forced decompositions of commercial-sized packages of *VAZO* 52 have been run by heating with a Nichrome ignition wire placed inside the drum 1 inch (2.5 cm) from the bottom. With a 25-30 amp current, smoke appeared near the base of the drum after a few moments, and the lid was then immediately blown about 5 meters into the air. Moments later a dense white cloud of *VAZO* 52 and decomposition products formed. The container remained upright throughout.

Fire Hazards

VAZO® polymerization initiators are flammable solids that can be ignited with an open flame or a continuous electric arc. Combustion is bright and complete as long as the *VAZO* is provided with air. The autoignition temperatures are 225°C for *VAZO* 52, 295°C for *VAZO* 64 and 185°C for *VAZO* 67, as measured by the spinning-disc method. This method measures the temperature at which the first visible flash appears in a mixture of dust and air. On a hot bar, *VAZO* 64 gives a range of temperatures, 140-440°C depending on the amount of *VAZO* present and the rate of heating.

Although *VAZO* is hydrophobic and floats on water, water is nevertheless the best treatment for large fires. These are difficult or impossible to extinguish; the rapid evolution of gas creates turbulence that makes it impossible to exclude oxygen completely. It is essential, therefore, to cool adjacent drums that are not yet burning, and thus prevent the fire from spreading. Sprinklers or remote-controlled deluge should be provided for this purpose. Fires should be fought from a distance since the self-accelerating decomposition, brought on by the heat of the fire, can expel the contents of the drums violently. Evacuate the area and fight fires from upwind.

Small fires may be extinguished by any of the common methods.

Precautions should be taken to avoid exposure to smoke and fumes from burning *VAZO* since toxic vapors may be present. An air mask, such as the Scott "Air Pak", should be worn when fighting a *VAZO* fire in any confined area where the fumes cannot be avoided.

Explosion Hazards

VAZO polymerization initiators are not shock sensitive. Solid material will not detonate or explode on impact, but dispersions in air can be explosive:

	***VAZO* 52**	***VAZO* 64**	***VAZO* 67**
Explosion pressure, psi	97	117	97
kPa	670	810	670
dp/dt max, psi/sec	12,500	10,280	10,000
MPa/s	86.2	70.9	69.0
dp/dt ave, psi/sec	3,400	4,000	3,300
MPa/s	23.4	27.6	22.8
Lower explosive limit (LEL), g/L	0.03	0.02	0.03
Minimum oxygen (O_2)%	9.5	—	9.5
Minimum ignition energy (MIE), joule	0.069	0.005	0.36

These dispersions in air are extremely easy to ignite and, in comparison with some other organic dusts, develop higher decomposition pressures at exceedingly rapid rates. In this respect, *VAZO* 64 is in the same class as aluminum and titanium powders. Care should be taken to avoid dusty conditions and, where they exist, to provide good ventilation and a sparkproof environment.

Pressure Vessel Test

The pressure vessel test indicates the force of a thermal decomposition. *VAZO*® Polymerization Initiators were compared with peroxides by heating in a sealed vessel with nitrogen atmosphere until decomposition occurred. The temperature at which autodecomposition began, the maximum pressure developed during decomposition, and the rate of pressure increase are given in Table V.

VAZO 52 behaves similarly to lauroyl peroxide, and shows much lower maximum pressures and rates of pressure development than diisopropyl peroxydicarbonate. *VAZO* 64 and *VAZO* 67 have intermediate severities, closer to that of *VAZO* 52 than to the percarbonate.

Pipe Propagation Test

This test determines if a thermally induced decomposition will propagate through a process line. Twenty percent (by wt) solutions of *VAZO* 52 were tested. A 500 mL vessel and attached tubing (17 millimeters i.d. × 1.5 meters) were tipped to an approximate 45° angle so that the tubing was filled with the solution in contact with the liquid in the test vessel. A transducer in the vessel and thermocouples in both the vessel and associated tubing were used to detect pressure and temperature changes; a temperature rise in the tubing would indicate decomposition. Data were continuously recorded. The vessel was heated until decomposition started. No significant temperature changes were detected in the tubing, indicating no propagation. *VAZO* 64 and *VAZO* 67 have not been subjected to this test.

Hazards of Solutions

Solutions of *VAZO* at concentrations used in polymerizations (usually 1% or less) present no unusual problems. More concentrated solutions (10% or higher), which are sometimes used to feed initiators into a process, can present a hazard if heated or exposed to hot surfaces. The heat liberated on decomposition, calculated from bond energy data,[16] is about 50 kcal/g mol or 210 kJ/g mol. This can further raise the temperature of the solution which, under some conditions of solvent, concentration and heat loss or cooling, can become self-heating; runaway reaction can occur.

This self accelerating decomposition is thought to be the explanation for the accident that was reported[17] with a 30% *VAZO* 64 solution in acetone. Acetone solutions have since been studied and no unexpected or unusual property or reaction was found compared to concentrated solutions of *VAZO* 64 in other solvents.

These cautionary notes are particularly important for *VAZO* 67 which is often used primarily because of its high solubility. Users are therefore likely to make quite concentrated solutions, which can have SADTs close to that of the dry initiator. We have seen no exotherm in a 30% solution held at 30°C for two weeks, but we nevertheless recommend avoiding all elevated temperatures.

When any of these initiators is used at concentrations higher than 10%, provision should be made for cooling mix tanks, pumps and lines. Because of the possibility of producing nitrogen, pumps and lines should be designed so that it is not possible to isolate any volume of solution, e.g. by closing two valves in one line.

WASTE DISPOSAL

Small spills of *VAZO*® should be swept up promptly, without raising dust, and may be destroyed in several ways:

- Spread out on paper or with other combustible material in an open area and ignite.
- Dissolve, for example in waste liquid, and incinerate. (See Hazards of Solutions above)
- Carefully feed the solid at a slow rate to an incinerator.
- Refrigerate and call Du Pont to discuss disposal options.

The floor area should then be flushed with water to a chemical sewer.

Large quantities of waste *VAZO* should be returned to Du Pont for disposal. Disposal information may be obtained by calling (302) 999-4153 or 4407.

TABLE V
PRESSURE VESSEL TEST RESULTS
FOR
VINYL POLYMERIZATION INITIATORS IN NITROGEN
Eight grams of initiator or solution in
80 mL test vessels unless otherwise stated

Initiator	Maximum Pressure ΔP, psi	(MPa)	(dp/dt) Max. psi/sec	(MPa/s)	Autodecomposition Temperature °C
VAZO® 52*	782	(5.4)	1,040	(7.2)	70
VAZO® 64*	1,050	(7.2)	40,000	(276)	103
VAZO® 67*	782	(5.4)	6,930	(44)	85
20% *VAZO* 52 in toluene	60	(0.41)	**		85†
Diisopropyl peroxydicarbonate	2,720	(18.8)	855,000	(5895)	33
20% Diisopropyl peroxydicarbonate in toluene	70	(0.48)	25	(0.17)	88†
Lauroyl peroxide	~385	(~2.7)	**		82
	415	(2.9)	1,570	(10.8)	82
20% Lauroyl peroxide in toluene	22	(0.15)	**		125†

* Ten grams of initiator in 100 mL test vessels.
** Instrument setting precluded measurement.
† Initiation difficult to detect.

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Chemicals and Pigments Department
Chestnut Run
Wilmington, DE 19898

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E. I. du Pont de Nemours and Company
Haskell Laboratory for Toxicology and Industrial Medicine

HASKELL LABORATORY REPORT NO. _____

Material Tested: 2,2'-Azobis (Isobutyronitrile) Haskell No.

Sample Ready for Testing: 12-15-75

IN VITRO MICROBIAL MUTAGENICITY STUDIES OF 2,2'-AZOBIS(ISOBUTYRONITRILE)

Materials and Methods: Five histidine-requiring strains of Salmonella typhimurium were used in the mutagen assays. Strains TA 1535 and TA 100 are used to detect base-pair substitution mutations, whereas strains TA 1537, TA 1538 and TA 98 are used to detect frame-shift mutations.

The tests were performed in the presence and absence of a rat-liver homogenate activation system (S·9). In the absence of metabolic activation, 0.1 ml of a solution of the test compound and approximately 10^8 bacteria were added to 2 ml of top agar (0.6% agar, 0.6% NaCl, 0.05 mM L-histidine, 0.05 mM biotin). The solution was mixed and poured on the surface of a Davis minimal agar plate. The metabolic activation system involved the addition of 0.5 ml of S·9 mixture to the chemical-top agar solution. The S·9 mix contains per ml: 0.3 ml of the 9,000 X g supernatant of homogenized rat liver, 8 mM $MgCl_2$, 33 mM KCl, 5 mM glucose-6-phosphate, 4 mM NADP and 100 mM sodium phosphate (pH 7.4). This mixture was added directly to the top agar immediately before it was poured over the minimal agar plate.

Prior to testing for mutagenicity, the compound was tested for toxicity to the tester strains.

Appropriate controls were included for each strain. In the nonactivated system these controls consisted of a negative, or solvent control, and positive controls. A second negative control (-S·9 control) is included in the activated assay to measure any activity of the compound in the absence of the S·9 activator mixture.

All plates were incubated at 37°C for 48 hours.

Results: Tables I and II.

Summary: 2,2'-Azobis(Isobutyronitrile) was tested in Salmonella typhimurium strains TA 1535, TA 1537, TA 1538, TA 98 and TA 100 in concentrations up to 2500 µg per petri plate in the activated plate test and 5000 µg per petri plate in the nonactivated plate test. The compound was not mutagenic in the microbial assays either in the presence or absence of a liver microsomal activation system (S·9 mixture), i.e., it did not significantly increase the spontaneous, or background, mutation frequency.

Report by: Frances C. Barsky

Frances C. Barsky
Biologist

Approved by: Byron E. Butterworth

Byron E. Butterworth
Chief, Microbiology Section

FCB:BEB:ljm

Date: February 24, 1976

T 3 I

MUTAGENIC ACTIVITY OF 2,2'-AZOBIS (ISOBUTYRONITRILE) IN S. TYPHIMURIUM STRAINS TA 1535, TA 1537, TA 1538, TA 98 AND TA 100 WITH METABOLIC ACTIVATION

Compound Added	Histidine$^+$ Revertants Per Plate**				
	TA 1535	TA 1537	TA 1538	TA 98	TA 100
DMSO	16	14	35	30	207
-S-9*	18	5	15	15	173
10,002 µg/Plate					
50 "	16	11	20	42	178
100 "	11	13	22	36	201
250 "	7	NT	NT	NT	201
500 "	17	11	24	34	179
750 "	18	12	24	40	177
1000 "	8	14	27	26	183
2500 "	NT	12	25	27	NT
2AA 100 µg/Plate	324	381			
10 "			~ 2500	~ 3000	
5 "					~ 2141

DMSO = Dimethylsulfoxide (Solvent Control).

10,002 = 2,2'-Azobis(isobutyronitrile).

2AA = 2-Aminoanthracene (Positive Control).

* = Control plate without S-9 activators.

** = Average number of revertants from two plates.

NT = Not tested.

TABLE II

MUTAGENIC ACTIVITY OF 2,2'-AZOBIS(ISOBUTYRONITRILE) IN S. TYPHIMURIUM STRAINS TA 1535, TA 1537, TA 1538, TA 98 AND TA 100 WITHOUT METABOLIC ACTIVATION

Compound Added	Histidine$^+$ Revertants Per Plate*				
	TA 1535	TA 1537	TA 1538	TA 98	TA 100
DMSO	26	9	11	29	207
10,002 µg/Plate					
100 "	20	12	14	23	187
500 "	20	12	17	22	173
750 "	29	8	13	25	163
1000 "	21	10	12	22	192
2500 "	23	8	11	19	170
5000 "	20	7	12	19	170
MNNG 2 µg/Plate	~ 3475				~ 4740
9AAc 50 "		~ 500			
2NF 25 "			~ 2600	~ 3400	

DMSO = Dimethylsulfoxide (Solvent Control).

10,002 = 2,2'-Azobis(isobutyronitrile).

MNNG = N-Methyl-N'-Nitro-N-Nitrosoguanidine (Positive Control).

9AAc = 9-Aminoacridine (Positive Control).

2NF = 2-Nitrofluorene (Positive Control).

* = Average number of revertants from two plates.

E. I. du Pont de Nemours and Company
Haskell Laboratory for Toxicology and Industrial Medicine

HASKELL LABORATORY REPORT NO.

Material Tested: "Vazo" Vinyl Polymerization Catalyst (α,α'-azobisisobutyronitrile 90-95%) Haskell No.:

INHALATION TOXICITY TEST - ACUTE

Technique: A weighed amount of material was placed in a deVilbiss continuous flow nebulizer. A dry air stream carried the dust particles from the nebulizer to an 8-liter bell jar containing 4 CHR-CD male rats, initial body weight 266-345 gm, via a rubber hose. The nebulizer was clamped onto a Boerner shaker during exposure in order to keep the material in motion.

Nominal Concentration (mg/L)	Air Flow (L/min)	Wt. Loss of Nebulizer (gm)	Time of Exposure (hrs)	Mortality Ratio	Fate
12	10	28.8	4	0/4	Killed 14 days after exposure.
9	7	15.2	4	0/4	Killed 14 days after exposure.
8	5	9.6	4	0/4	Killed 15 days after exposure.

Clinical Observations: The approximate lethal concentration of "Vazo" is greater than 12 mg/L for 4 hours*. During exposure to sublethal concentrations of the dust, rats showed deep breathing, eye irritation, discomfort and pallor. After exposure, nervousness, ruffled fur and weight losses were observed in the rats from 1 to 4 days.

Pathological Findings: Microscopic examination of the tissues two weeks after exposure revealed mild hyaline granular degeneration of the kidney tubules in rats of all exposed groups and slight hypotrophy of the thymic medulla in the group exposed to the highest concentration. Significant changes were not found in the lungs and enzootic pneumonitis did not appear to be aggravated.

* The above technique did not warrant the use of air flows higher than 10 L/min, therefore, further exposures at a higher concentration were not possible.
Calculated from weight loss of nebulizer and air flow.

SKIN IRRITATION AND SENSITIZATION TESTS

Method: Irritation tests were done by topical application to the intact skin of albino guinea pigs. In the test for sensitization, a series of nine exposures to abraded skin was followed by a two-week rest period and challenge test.

Results:

Concentration	Irritation	Sensitization
25% ointment in "Carbowax" 1500	Occasional mild erythema (1/10)	0/10
10% ointment in "Carbowax" 1500	No irritation	
25% suspension in dimethyl phthalate	No irritation	
10% suspension in dimethyl phthalate	No irritation	

Summary: There was no evidence of significant irritation or sensitization of the skin of guinea pigs.

EYE IRRITATION TESTS

Method: Male albino rabbits received doses of 10 mg either as the powder sprinkled on the surface of each eye or as a suspension in propylene glycol instilled with a syringe. The left eyes were washed with tap water twenty seconds after contact; the right eyes were not washed.

Results:

Dose	Contact	Clinical Effect During 7-Day Observation Period
10 mg powder	Left eye, washed	Mild conjunctival inflammation day of treatment.
	Right eye, not washed	Mild conjunctival inflammation day of treatment.
0.1 ml 10% suspension	Left eye, washed	Mild conjunctival irritation through 4 days.
	Right eye, not washed	Mild conjunctival irritation through 4 days.

Summary: Rabbit eye tests showed that "Vazo" either as the powder received or as a suspension in propylene glycol, produced temporary conjunctival irritation but no corneal or iritic injury.

Conclusions: "Vazo" or α,α'-azobisisobutyronitrile has low acute inhalation toxicity, the ALC for 4 hours being greater than 12 mg/L. The oral ALD was 670 mg/kg of body weight (Haskell Report No. 27-62). There has been no evidence of permanent damage to the tissues of survivors exposed by either route.

"Vazo" was not irritating to guinea pig skin nor did it produce sensitization. It was mildly irritating to the conjunctivae of the rabbit and rat eye, but it did not injure the cornea or iris.

Report by: Donald B. Clayton

Approved by: Wesley Clayton Jr.

November 14, 1962

E. I. du Pont de Nemours and Company
Haskell Laboratory for Toxicology and Industrial Medicine

HASKELL LABORATORY REPORT NO.

Material Tested: Azobisisobutyronitrile — Haskell No.: 2689 and 2735

Other Codes: "Vazo", QY-602

ACUTE ORAL TEST

Procedure: The test material was administered by stomach tube as a suspension in acetone:peanut oil (1:9) in single doses to young adult ChR-CD male or female rats. Survivors were killed 10-11 days later.

% Suspension	Sex	Dose (mg/kg)	Mortality*	Toxic Signs	Pathological Changes	ALD
			H-2689			
20	M	2250	D - 2 d.	Lethal Doses: Discomfort, irritability, inactivity, convulsions, weight loss, slight polyuria Nonlethal Doses: Discomfort, irritability, weight loss	Lethal Doses: Liver damage, congestion of brain, kidney damage at two highest levels Nonlethal Doses: None	670 mg/kg
20	M	1500	D - 7 d.			
20	M	1000	D - 2 d.			
10	M	670	D - 6 d.			
10	M	450	S - 11 d.			
10	M	300	S - 11 d.			
10	M	200	S - 11 d.			
10	M	130	S - 11 d.			
			H-2735			
20	M	1500	D - 8 d.	Lethal Doses: Discomfort, inactivity, irritability, weight loss, tremors, convulsions Nonlethal Doses: Discomfort, irritability, weight loss	Lethal Doses (Gross): Injury to liver, lungs, brain and stomach Nonlethal Doses (Gross): None	670 mg/kg
20	M	1000	D - 6 d.			
10	M	670	D - 4 d.			
10	M	450	S - 11 d.			
10	M	300	S - 10 d.			
10	M	130	S - 10 d.			

*( ) d = Found dead ( ) days after dosing
( ) d = Sacrificed ( ) days after dosing

Animal Number	Sex	Dose (mg/kg)	Mortality *	Toxic Signs	Pathological Changes	ALD
			H-2735			
5	F	670	D - 2 d.	Lethal Doses: Discomfort, tremors, weight loss Nonlethal Doses: Irritability, weight lose	Lethal Doses (Gross): Injury to stomach and lungs Nonlethal Doses (Gross): None	450 mg/kg
5	F	450	D - 3 d.			
3	F	300	S - 10 d.			
3	F	200	S - 10 d.			

Conclusions:

Azobisisobutyronitrile is moderately toxic when administered orally to male and female rats, its Approximate Lethal Dose (ALD) being 670 and 450 mg/kg of body weight, respectively. The compound appears to act on the central nervous system and liver. In addition, microscopic pathology indicates that the Du Pont product (H-2689) is injurious to the kidneys, and gross examination indicates that the competitive product (H-2735) causes injury to the stomach.

The present ALD values for both products confirm that obtained for a similar product tested on male rats at the Haskell Laboratory in 1947. (Report No. 25-47). The ALD of 450 mg/kg for females does not denote a different order of toxicity. Neither the ALD value for the Du Pont product nor that of the product made by the Whiffen Company, which is purported to have been prepared by a process very similar to that used by I.C.I., confirm the value obtained by I.C.I., who reported a minimum lethal dose for rats of 40 mg/kg for azobisisobutyronitrile.

Report by: Henry Sherman

Approved by: Wesley Stanton

HS/ohl
7/15/62

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REVISED REPORT

E. I. du Pont de Nemours and Company
Haskell Laboratory for Toxicology and Industrial Medicine
Elkton Road, Newark, Delaware 19711

HASKELL LABORATORY REPORT NO. _____

Material Tested	Haskell No.	Other Codes
Propanenitrile, 2,2'-azobis(2-methyl-*		Vazo® 64

Study Initiated/Completed
11/5/79-11/30/79

INHALATION SUBACUTE

Introduction: The purpose of this study was to evaluate the subacute inhalation toxicity of Vazo® 64 on male Crl:CD® rats. Prior to initiating the subacute study, range finding exposures determined the 4-hour ALC (Approximate Lethal Concentration) to be 950 mg/m^3. Design levels for these experiments were 0 mg/m^3 (Group I), 10.0 mg/m^3 (Group II), and 80.0 mg/m^3 (Group III).

Procedure: Male Crl:CD® rats were exposed via inhalation to atmospheres of Vazo® 64 in air. Groups of 10 rats, 8 weeks old and weighing 240 to 257 grams were restrained in wire mesh holders and exposed head-only in 50 liter glass chambers. The total exposure was 6 hours/day, 5 days/week, for 2 weeks. Five rats/group were randomly selected for sacrifice after the 10th exposure. The remaining 5 rats/group were sacrificed after a 14-day recovery-observation period.

Except during exposure, the rats were housed in pairs with Purina Certified Rodent Chow® #5002 and water available ad libitum. All rats were quarantined for a 1-week pre-test period to assure that they had a normal rate of growth and no overt manifestations of disease. Rats were weighed and observed daily (except weekends) throughout the exposure and recovery period.

Generation: Dust atmospheres of Vazo® 64 were generated by passing air through a 2-stage glass generator composed of a dust reservoir and a cyclone generator. An electric motor and steel rod with plastic paddles agitated both stages. A second stream of houseline air carried the airborne dust into the exposure chamber.

Analytical: Calibrated volumes of chamber atmosphere were drawn through Gelman glass fiber filters (Type A-E, 47 mm). Atmospheric concentration of test material was determined from weight gain of the filters. Chamber atmosphere samples were collected at 60 minute intervals from the high level. Due to the low design concentration, a maximum of 3 samples at approximately 120 minute intervals could be collected from the low level.

Once during each exposure (high level only), the mass median diameter of the dust atmosphere was determined with a Sierra cascade impactor.

Clinical Chemistry: After exposure 9 and recovery day 13, all rats were housed in metabolism racks for overnight urine collection. After exposure 10 and recovery day 14, blood samples were taken from the tails of all rats. Detailed clinical chemistry procedures and indices are listed in the clinical chemistry report (1).

Pathology: After the 10th exposure, 5 rats from each group were selected at random and sacrificed for gross and histopathological examination. Remaining rats were sacrificed on the 14th day of recovery for an identical follow-up examination. Pathological procedures and indices are included in the pathology report (2).

Organ and Body Weight Analysis: For each sacrifice, organ weights and organ-to-body weight ratios were determined for the heart, lungs, liver, spleen, kidney, testes, and thymus (Appendix II).

Results:

Chamber oxygen was $\geq$20% during all exposures. Chamber temperature was $\leq$28 °C for all exposures.

A. Exposure Data

Exposure No.	TWA Concentration (Range) mg/m^3 Group II	TWA Concentration (Range) mg/m^3 Group III	Mass Median Diameter (u) (Group III Only)
1	6.8 (6.1-8.2)	86.8 (64.0-120.0)	-
2	12.0 (8.6-15.9)	83.8 (59.0-116.0)	11.5
3	8.2 (4.8-13.3)	73.0 (60.0-82.1)	10.6
4	9.7 (6.0-14.4)	71.8 (46.0-134.0)	10.2
5	8.5 (5.2-12.7)	83.8 (70.0-100.0)	8.1
6	10.4 (5.3-13.8)	73.8 (50.0-110.0)	7.8
7	10.0 (7.4-12.7)	73.8 (60.9-85.0)	10.0
8	10.6 (5.9-14.4)	80.4 (62.0-106.0)	9.7
9	8.2 (5.0-10.4)	83.3 (71.1-105.0)	9.8
10	13.8 (7.7-17.0)	80.3 (59.0-120.0)	8.0
Mean†	9.80	79.5	
S.D.	3.70	17.9	

† Mean of all samples from 10 exposures.

B. Clinical Observations

One Group III rat was sacrificed, in extremis, following the 4th exposure. This rat exhibited lung noise, poor righting reflex, stained fur, labored breathing, and sluggishness prior to sacrifice.

This rat was unlike all other rats (test and control) in that the only clinical observations of all other rats were slight red ocular and nasal discharge during exposure. These signs are common in animal appearance when under restraint.

C. Clinical Chemistry

Exposed groups tended to have higher serum total proteins than the unexposed controls. Urine osmolality was lower in Group III rats.

No effect was seen in Group II after the 14-day recovery period. Group III rats continued to have higher serum total proteins. Other differences between control and treated rats were judged unrelated to the exposure to Vazo® 64.

D. Pathology

In Group III, one rat was sacrificed in extremis after the 4th exposure. The cause was not explained by pathologic examination. This death is not attributed solely to compound administration since animals restrained in this fashion are occasionally injured, sometimes resulting in extremis condition or death.

The 4 Group III rats sacrificed after the 10th exposure exhibited a compound-related liver effect, increased cytoplasmic basophilia of hepatocytes. This liver effect was not detected in Group III rats following a 2-week recovery period nor in Group II rats at any time.

E. Body and Organ Weight Analysis

When compared with controls, Group II rats showed a normal rate of weight gain during both the exposure and recovery periods. However, mean body weights of Group III rats were significantly below controls on day 2 through day 4 of the exposure period. Even after deleting the weights of the rat sacrificed in extremis, the mean body weight of this group was significantly lower than the controls on days 2 through day 4 of the exposure period. For the remainder of the exposure and recovery period, Group III rats showed a normal rate of weight gain (see Appendix I and Figure I).

There was a dose related increase in liver-to-body weight ratios after 10 exposures. This effect was no longer evident after the 14-day recovery period.

Summary: Groups of 10 male Crl:CD® rats were exposed 6 hours/day, 5 days/week for 2 weeks to concentrations of either 9.8 (Group II) or 79.5 mg/m^3 (Group III) of Vazo® 64 in air. A control group (Group I) was simultaneously exposed to air only.

During the 6 hour exposure period, clinical observations of exposed rats were indistinguishable from controls with the exception of one Group III rat which was sacrificed *in extremis* following the 4th exposure. This rat exhibited lung noise, poor righting reflex, stained fur, labored breathing, and sluggishness prior to sacrifice.

When compared with control rats, Group II rats showed a normal rate of weight gain during the entire test period. Mean body weight of Group III rats was significantly below controls on day 2 through day 4 of the exposure period. For the remainder of the test period, Group III rats showed a normal rate of weight gain.

All exposed rats tended to have higher serum total proteins than the unexposed controls after 10 exposures. Urine osmolality was lower in Group III rats. Following the 14-day recovery period, no effect was seen in Group II rats. However, Group III rats continued to have higher serum total proteins.

Comparison with controls indicated no compound related pathological lesions in Group II rats. The 4 Group III rats sacrificed after the 10th exposure exhibited a compound-related liver effect, increased cytoplasmic basophilia of hepatocytes. However, this liver effect was not detected in Group III rats following a 14-day recovery period.

The mean relative liver-to-body weight ratios of exposed rats was significantly higher than the control group after exposure 10. This effect was no longer evident after a 14-day recovery period.

---

* Composition:

99.0%	2,2'-Azobis(2-methylpropanenitrile)
0.11%	Water
6.3 ppm	Iron
0.04%	Acetone insolubles

(1) Bobby L. Moore and John R. Barnes, "Inhalation Toxicity Testing of Vazo® 64," H-13,259, January 16, 1980.

(2) Hans H. C. Chen and William C. Krauss, Haskell Pathology Report No. 31-80, H-13,259, October 6, 1980.

Report by: Stephen D. Nash
Stephen D. Nash
Technician

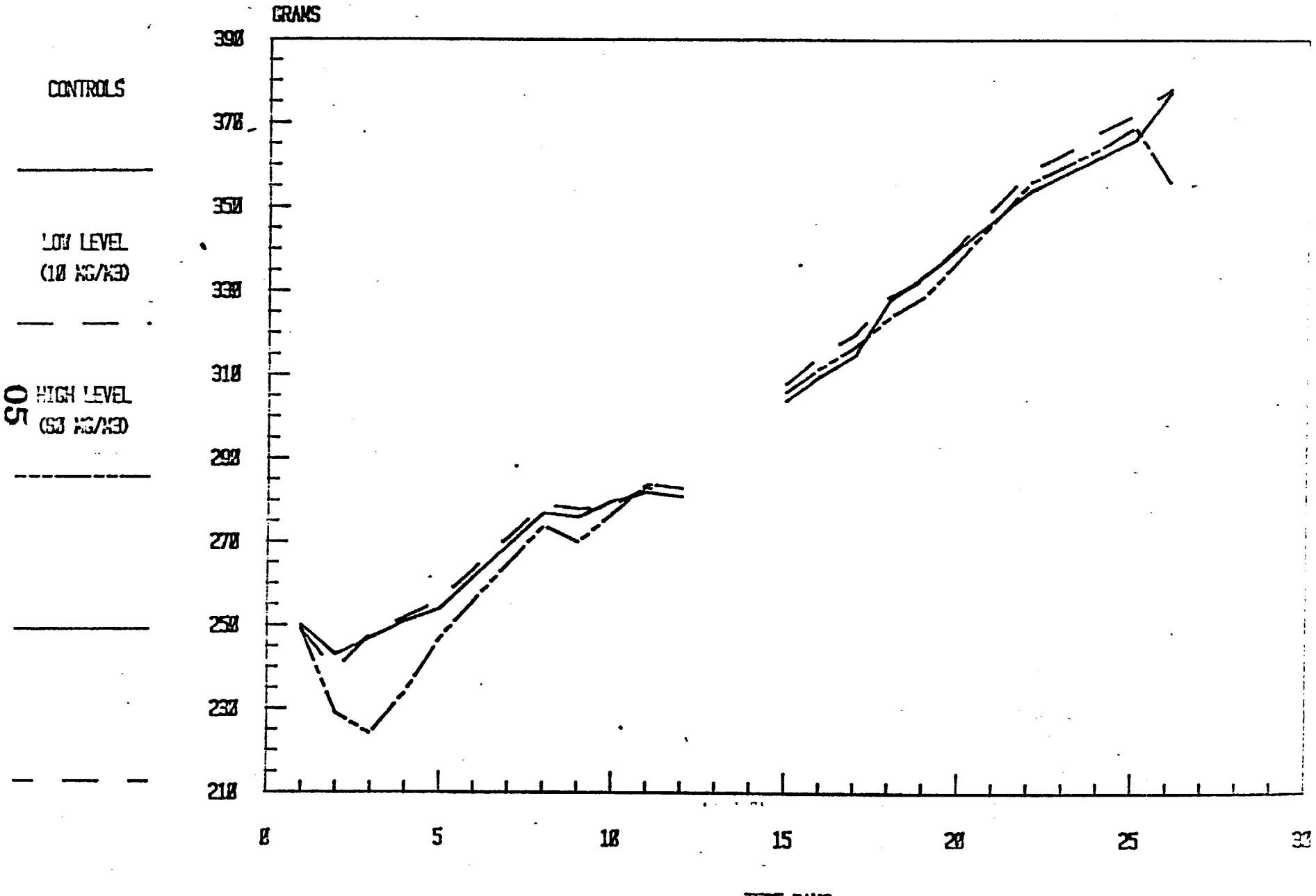
Approved by: Gerald L. Kennedy
Gerald L. Kennedy
Chief, Acute Investigations Section

SDN:vlm
Study Director: M. R. Brittelli
Date Issued: March 11, 1981
Date Reissued: June 3, 1981

Report No.

VAZO 64 2-WK SUBACUTE WGT. GROWTH CURVE

H# 13259



APPENDIX I

INTERVALS IN TEST DAYS

GROUP	1.	2.	3.	4.	5.
ONTROLS	249.9000	242.8000	247.1000	251.4000	253.5000
OW LEVEL(10 MG/M3)	249.1000	239.1000	248.0000	252.3000	255.6000
IGH LEVEL(80 MG/M3)	249.4444	229.3333#	224.2222#	234.0000#	246.7778
F RATIO(1)	0.048	7.558*	16.256*	8.925*	2.335
LSD(2)	5.4089	7.2476	9.5474	9.8634	8.6315
DUNNETT(3)	6.1049	8.1803	10.7759	11.1327	9.7421
WMS(4)	33.3855	59.9423	104.0175	111.0192	85.0175

INTERVALS IN TEST DAYS

GROUP	8.	9.	10.	11.	12.
ONTROLS	276.9000	276.0000	279.7000	282.4000	281.2000
OW LEVEL(10 MG/M3)	278.8000	278.4000	278.7000	282.9000	284.7000
IGH LEVEL(80 MG/M3)	273.8889	270.4444	276.6667	283.5556	283.4444
F RATIO(1)	1.050	2.028	0.273	0.034	0.327
LSD(2)	6.9409	8.2116	8.4852	9.0602	9.1682
DUNNETT(3)	7.8341	9.2682	9.5771	10.2261	10.3480
WMS(4)	54.9765	76.9470	82.1615	93.6739	95.9201

INTERVALS IN TEST DAYS

GROUP	15.	16.	17.	18.	19.
ONTROLS	304.2000	310.0000	314.8000	327.8000	333.6000
OW LEVEL(10 MG/M3)	307.8000	315.4000	320.2000	328.6000	333.6000
IGH LEVEL(80 MG/M3)	306.0000	312.0000	316.8000	324.2000	328.6000
F RATIO(1)	0.121	0.240	0.240	0.194	0.169
LSD(2)	15.9495	17.1614	17.1670	16.4053	21.6627
DUNNETT(3)	18.3007	19.6914	19.6977	18.8237	24.8563
WMS(4)	133.9667	155.1000	155.2000	141.7333	247.1333

DIFFERENCES IN 11 T DAYS

GROUP	22.	23.	24.	25.	26.
CONTROLS	353.6000	357.6000	362.2000	366.0000	376.8000
LOW LEVEL(10 MG/M3)	359.2000	363.2000	367.6000	372.2000	378.0000
HIGH LEVEL(80 MG/M3)	356.0000	360.2000	364.4000	369.0000	356.4000
F RATIO(1)	0.146	0.157	0.152	0.209	2.908
LSD(2)	22.6777	21.7982	21.4631	20.9089	21.9328
DUNNETT(3)	26.0208	25.0117	24.6272	23.9913	25.1661
WMS(4)	270.8333	250.2333	242.6000	230.2333	253.3333

(1) RATIO OF AMONG- TO WITHIN-GROUP VARIATION--ONE-FACTOR ANALYSIS OF VARIANCE

(2) LEAST SIGNIFICANT DIFFERENCE--GIVEN A SIGNIFICANT (ALPHA=0.05) F RATIO, ANY TWO MEANS DIFFERING BY MORE THAN THE LSD ARE SIGNIFICATLY DIFFERENT WITH A VARIABLE-WISE FALSE POSITIVE (ALPHA) ERROR RATE OF 0.05.

(3) DUNNETT TEST--ANY TREATMENT MEAN DIFFERING FROM THE CONTROL MEAN BY MORE THAN THE DUNNETT STATISTIC IS SIGNIFICANTLY DIFFERENT FROM THE CONTROL MEAN WITH A VARIABLE-WISE FALSE POSITIVE (ALPHA) ERROR RATE OF 0.05.

(4) WITHIN-GROUP MEAN SQUARE.

+ SIGNIFICANTLY DIFFERENT (P<0.05) FROM CONTROL GROUP BY LSD.

SIGNIFICANTLY DIFFERENT (P<0.05) FROM CONTROL GROUP BY DUNNETT TEST AND LSD.

* SIGNIFICANT AT THE 0.05 PROBABILITY LEVEL.

APPENDIX II

GROUP	FINAL WGT.	HEART	LUNGS	LIVER	SPLEEN
ONTROLS	282.6000	1.1040	1.6540	10.3140	.5460
OW LEVEL(10 MG/M3)	278.6000	1.0480	1.6280	13.9620#	.5800
IGH LEVEL(80 MG/M3)	281.5000	1.0050	1.6000	16.6075#	.6000
F RATIO(1)	.123	1.281	.078	58.272*	.794
LSD(2)	19.0389	.1350	.2963	1.2757	.0946
DUNNETT(3)	21.8048	.1552	.3406	1.4664	.1090
WMS(4)	172.6727	.0087	.0418	.7752	.0043

GROUP	KIDNEY	TESTIS	THYMUS
ONTROLS	2.5080	3.0760	.6980
OW LEVEL(10 MG/M3)	2.4380	2.9920	.6400
IGH LEVEL(80 MG/M3)	2.7475	3.1750	.6475
F RATIO(1)	1.489	2.995	.526
LSD(2)	.4004	.1615	.1394
DUNNETT(3)	.4603	.1857	.1602
WMS(4)	.0764	.0124	.0093

1) Ratio of among- to within-group variation--one-factor analysis of variance
2) Least significant difference--given a significant (alpha=0.05) F ratio, ny two means differing by more than the LSD are significantly different ith a variable-wise false positive (alpha) error rate of 0.05.
3) Dunnett test--Any treatment mean differing from the control mean by more han the Dunnett statistic is significantly different from the control mean ith a variable-wise false positive (alpha) error rate of 0.05.
4) Within-group Mean Square.
Significantly different (P<0.05) from control group by LSD.
Significantly different (P<0.05) from control group by Dunnett test nd LSD.
Significant at the 0.05 probability level.

GROUP	HEART	LUNGS	LIVER	SPLEEN	KIDNEY
ONTROLS	.3904	.5860	3.6475	.1933	.8852
OW LEVEL(10 MG/M3)	.3757	.5822	5.0457#	.2079	.8771
IGH LEVEL(80 MG/M3)	.3570	.5683	5.9026#	.2128	.9752
F RATIO(1)	2.187	.096	26.778*	1.380	1.705
LSD(2)	.0345	.0901	.6802	.0271	.1252
DUNNETT(3)	.0396	.1036	.7819	.0311	.1439
WMS(4)	.0006	.0039	.2204	.0003	.0075

GROUP	TESTIS	THYMUS
ONTROLS	1.0888	.2472
OW LEVEL(10 MG/M3)	1.0783	.2291
IGH LEVEL(80 MG/M3)	1.1282	.2305
F RATIO(1)	.765	.455
LSD(2)	.0905	.0479
DUNNETT(3)	.1040	.0550
WMS(4)	.0039	.0011

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Significantly different (P<0.05) from control group by LSD.
Significantly different (P<0.05) from control group by Dunnett test nd LSD.
Significant at the 0.05 probability level.

GROUP	FINAL WGT.	HEART	LUNGS	LIVER	SPLEEN
ONTROLS	376.8000	1.2980	2.0700	15.2800	.8860
OW LEVEL(10 MG/M3)	378.0000	1.3340	2.3540	14.1120	.9040
IGH LEVEL(80 MG/M3)	356.4000	1.2640	2.0740	14.2260	.7780
F RATIO(1)	2.908	.314	2.068	.702	1.282
LSD(2)	21.9328	.1924	.3489	2.3675	.1854
DUNNETT(3)	25.1661	.2208	.4003	2.7166	.2126
WMS(4)	253.3333	.0195	.0641	2.9519	.0181

GROUP	KIDNEY	TESTIS	THYMUS
ONTROLS	3.2100	3.3820	.7680
OW LEVEL(10 MG/M3)	3.0480	3.3660	.8840
IGH LEVEL(80 MG/M3)	3.0700	3.3900	.6980
F RATIO(1)	.437	.016	2.742
LSD(2)	.4095	.2951	.1748
DUNNETT(3)	.4699	.3386	.2006
WMS(4)	.0883	.0459	.0161

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4) Within-group Mean Square.
Significantly different (P<0.05) from control group by LSD.
Significantly different (P<0.05) from control group by Dunnett test nd LSD.

GROUP	HEART	LUNGS	LIVER	SPLEEN	KIDNEY
NTROLS	.3444	.5491	4.0457	.2344	.8515
W LEVEL(10 MG/M3)	.3529	.6244	3.7368	.2398	.8052
GH LEVEL(80 MG/M3)	.3539	.5800	3.9789	.2179	.8605
F RATIO(1)	.137	1.788	1.148	.618	1.305
LSD(2)	.0437	.0872	.4673	.0446	.0800
DUNNETT(3)	.0501	.1000	.5362	.0512	.0918
WMS(4)	.0010	.0040	.1150	.0010	.0034

GROUP	TESTIS	THYMUS
NTROLS	.8986	.2045
W LEVEL(10 MG/M3)	.8916	.2336
GH LEVEL(80 MG/M3)	.9516	.1946
F RATIO(1)	1.458	2.149
LSD(2)	.0837	.0426
DUNNETT(3)	.0961	.0489
WMS(4)	.0037	.0010

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